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Telewavesim: Python software for teleseismic body wave modeling

Pascal Audet[1], **Colin J. Thomson**[2, 3], **Michael G. Bostock**[4], **and Tom Eulenfeld**[5]

1 Department of Earth and Environmental Sciences, University of Ottawa, Canada **2** Sherlock Seismic Solutions, Cambridge, U.K. **3** Formerly Schlumberger Cambridge Research, U.K. **4** Department of Earth, Ocean and Atmospheric Sciences, The University of British Columbia, Canada **5** Institute of Geosciences, Friedrich Schiller University Jena, Germany

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Summary

The structure of the Earth's crust and upper mantle provides useful information on the internal composition and dynamics of our planet. Some of the most widely used techniques to infer these properties are based on examining the effect of teleseismic body wave (i.e., P and S waves that originate from distant earthquakes and arrive as plane waves) propagation through stratified media. Modeling the seismic response from stacks of subsurface layers is therefore an essential tool in characterizing their effect on observed seismograms. Although a few established techniques are available for this purpose (e.g., Frederiksen & Bostock (2000)), these are either based on approximations or else do not handle general anisotropy or the effect of an overlying fluid medium.

`telewavesim` is a Python package for synthesizing teleseismic body-wave propagation through stacks of generally anisotropic and strictly horizontal layers using the matrix propagator approach of Kennett (1983) and implemented by Thomson (1997). Python allows wrapping low-level Fortran routines for speed while maintaining flexibility and ease of use for code interaction and plotting. The integration of `obspy` (Krischer et al., 2015) `Stream` objects allows flexibility in manipulating and visualzing the resulting seismograms. The software contains a wide range of elastic stiffness definitions extracted from the literature (Brownlee et al., 2017) to accurately represent seismic anisotropy due to various mineralogies and rock types. The software also accurately models acoustic reverberations from an overlying column of water, effectively simulating ocean-bottom seismograph station recordings.

The software will be useful in a variety of teleseismic receiver-based studies, such as P or S receiver functions and shear-wave splitting from core-refracted teleseismic shear waves (i.e., SKS, SKKS). It may also be the starting point for stochastic inverse methods (e.g., Monte Carlo sampling) and more general (i.e., point) sources through slowness integration (Frazer & Gettrust, 1984). Common computational workflows that reproduce published examples (Audet, 2016; Porter, Zandt, & McQuarrie, 2011) are covered in the Jupyter notebooks bundled with this package. These notebooks can be further used in a teaching environment to study the effects of seismic wave scattering effects in stratified media. The API documentation is up-to-date on GitHub pages. `telewavesim` and all Python dependencies can be installed through the pypi.org `pip` package manager.

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